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## Using Device-provided Location-Related Measurements in Location Configuration Protocols

### draft-thomson-geopriv-held-measurements-06

#### Abstract

A method is described by which a Device is able to provide location-related measurement data to a LIS within a request for location information. Location-related measurement information are observations concerning properties related to the position of a Device, which could be data about network attachment or about the physical environment. When a LIS generates location information for a Device, information from the Device can improve the accuracy of the location estimate. A basic set of location-related measurements are defined, including common modes of network attachment as well as assisted Global Navigation Satellite System (GNSS) parameters.

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## 1. Introduction

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A location configuration protocol (LCP) provides a means for a Device to request information about its physical location from an access network. A location information server (LIS) is the server that provides location information; information that is available due to the knowledge about the network and physical environment that is available to the LIS.

As a part of the access network, the LIS is able to acquire measurement results from network Devices within the network that are related to Device location. The LIS also has access to information about the network topology that can be used to turn measurement data into location information. However, this information can be enhanced with information acquired from the Device itself.

A Device is able to make observations about its network attachment, or its physical environment. The location-related measurement data might be unavailable to the LIS; alternatively, the LIS might be able to acquire the data, but at a higher cost in time or otherwise. Providing measurement data gives the LIS more options in determining location, which could improve the quality of the service provided by the LIS. Improvements in accuracy are one potential gain, but improved response times and lower error rates are also possible.

This document describes a means for a Device to report location-related measurement data to the LIS. Examples based on the [HELD \(Barnes, M., Winterbottom, J., Thomson, M., and B. Stark, "HTTP Enabled Location Delivery \(HELD\)," August 2009.\)](#)

[I-D.ietf-geopriv-http-location-delivery] location configuration protocol are provided.

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## 2. Conventions used in this document

The terms LIS and Device are used in this document in a manner consistent with the usage in [\[I-D.ietf-geopriv-http-location-delivery\]](#) (Barnes, M., Winterbottom, J., Thomson, M., and B. Stark, "HTTP Enabled Location Delivery (HELD)," August 2009.).

This document also uses the following definitions:

**Location Measurement:** An observation about the physical properties of a particular Device's network access. The result of a location measurement—"location-related measurement data", or simply "measurement data" given sufficient context—can be used to determine the location of a Device. Location-related measurement data does not identify a Device; measurement data can change with time if the location of the Device also changes. Location-related measurement data does not necessarily contain location information directly, but it can be used in combination with contextual knowledge of the network, or algorithms to derive location information. Examples of location-related measurement data are: radio signal strength or timing measurements, Ethernet switch and port identifiers.

Location-related measurement data can be considered sighting information, based on the definition in [\[RFC3693\]](#) (Cuellar, J., Morris, J., Mulligan, D., Peterson, J., and J. Polk, "Geopriv Requirements," February 2004.).

**Location Estimate:** The result of location determination, a location estimate is an approximation of where the Device is located. Location estimates are subject to uncertainty, which arise from errors in measurement results.

**GNSS:** Global Navigation Satellite System. A satellite-based system that provides positioning and time information. For example, the US Global Positioning System (GPS) or the European Galileo system.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [\[RFC2119\]](#) (Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," March 1997.).

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## 3. Location-Related Measurements in LCPs

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This document defines a standard container for the conveyance of location-related measurement parameters in location configuration

protocols. This is an XML container that identifies parameters by type and allows the Device to provide the results of any measurement it is able to perform. A set of measurement schemas are also defined that can be carried in the generic container.

The simplest example of measurement data conveyance is illustrated by the example message in [Figure 1 \(HELD Location Request with Measurement Data\)](#). This shows a HELD location request message with an Ethernet switch and port measurement taken using [LLDP \(IEEE, "IEEE Standard for Local and Metropolitan area networks, Station and Media Access Control Connectivity Discovery," June 2005.\)](#) [IEEE.8021AB].

---

```
<locationRequest xmlns="urn:ietf:params:xml:ns:geopriv:held">
  <locationType exact="true">civic</locationType>
  <measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
    time="2008-04-29T14:33:58">
    <lldp xmlns="urn:ietf:params:xml:ns:geopriv:lm:lldp">
      <chassis type="4">0a01003c</chassis>
      <port type="6">c2</port>
    </lldp>
  </measurements>
</locationRequest>
```

**Figure 1: HELD Location Request with Measurement Data**

---

Measurement data that the LIS does not support or understand can be ignored. The measurements defined in this document follow this rule; extensions that could result in backward incompatibility MUST be added as new measurement definitions rather than extensions to existing types.

Multiple sets of measurement data, either of the same type or from different sources can be included in the measurements element. See [Section 4.1.1 \(Time of Measurement\)](#) for details on repetition of this element.

Use of location-related measurement data is at the discretion of the LIS, but the method parameter in the PIDF-LO SHOULD be adjusted to reflect the method used.

Location-related measurement data need not be provided exclusively by Devices. A third party location requester can request location information using measurement data, if they are able and authorized. There are privacy considerations relating to the use of measurements by third parties, which are discussed in [Section 7.4 \(Third-Party-Provided Measurement Data\)](#).

Location-related measurement data and its use presents a number of security challenges. These are described in more detail in [Section 8 \(Security Considerations\)](#).

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## 4. Location-Related Measurement Data Types

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A common container is defined for the expression of location measurement data, as well as a simple means of identifying specific types of measurement data for the purposes of requesting them.

---

The following example shows a measurement container with measurement time and expiration time included. A WiFi measurement is enclosed.

```
<lm:measurements xmlns:lm="urn:ietf:params:xml:ns:geopriv:lm"
    time="2008-04-29T14:33:58"
    expires="2008-04-29T17:33:58">
  <wifi xmlns="urn:ietf:params:xml:ns:geopriv:lm:wifi">
    <servingWap>
      <ssid>wlan-home</ssid>
      <bssid>00-12-F0-A0-80-EF</bssid>
    </servingWap>
  </wifi>
</lm:measurements>
```

**Figure 2: Measurement Example**

---

### 4.1. Measurement Container

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The measurement element is used to encapsulate measurement data that is collected at a certain point in time. It contains time-based attributes that are common to all forms of measurement data, and permits the inclusion of arbitrary measurement data.

This container can be added to any request for location information, such as a [HELD location request \(Barnes, M., Winterbottom, J., Thomson, M., and B. Stark, "HTTP Enabled Location Delivery \(HELD\)," August 2009.\)](#) [I-D.ietf-geopriv-http-location-delivery].

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#### 4.1.1. Time of Measurement

The time attribute records the time that the measurement or observation was made. This time can be different to the time that the measurement information was reported. Time information can be used to populate a timestamp on the location result, or to determine if the measurement information is used.

The time attribute is optional to avoid forcing an arbitrary choice of timestamp for relatively static types of measurement (for instance, the DSL measurements in [Section 5.6 \(DSL Measurements\)](#)) and for legacy Devices that don't record time information (such as the Home Location Register/Home Subscriber Server for cellular). However, time SHOULD be provided whenever possible.

The time attribute is attached to the root measurement element. If it is necessary to provide multiple sets of measurement data with different times, multiple measurement elements SHOULD be provided.

---

#### 4.1.2. Expiry Time on Location-Related Measurement Data

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A Device is able to indicate an expiry time in the location measurement using the expires attribute. Nominally, this attribute indicates how long information is expected to be valid for, but it can also indicate a time limit on the retention and use of the measurement data. A Device can use this attribute to prevent the LIS from retaining measurement data or limit the time that a LIS retains this information.

**Note:** Movement of a Device might result in the measurement data being invalidated before the expiry time.

The LIS MUST NOT keep location-related measurement data beyond the time indicated in the expires attribute.

---

#### 4.2. RMS Error and Number of Samples

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Often a measurement is taken more than once over a period of time. Reporting the average of a number of measurement results mitigates the effects of random errors that occur in the measurement process. Typically, a mean value is reported at the end of the measurement interval, but additional information about the distribution of the results can be useful in determining location uncertainty.

Two optional attributes are provided for certain measurement values:

**rmsError:** The root-mean-squared (RMS) error of the set of measurement values used in calculating the result. RMS error is



expressed in the same units as the measurement, unless otherwise stated. If an accurate value for RMS error is not known, this value can be used to indicate an upper bound for the RMS error.

**samples:** The number of samples that were taken in determining the measurement value. If omitted, this value can be assumed to be a very large value, so that the RMS error is an indication of the standard deviation of the sample set.

For some measurement techniques, measurement error is largely dependent on the measurement technique employed. In these cases, measurement error is largely a product of the measurement technique and not the specific circumstances, so RMS error does not need to be actively measured. A fixed value MAY be provided for RMS error where appropriate.

The `rmsError` and `samples` elements are added as attributes of specific measurement data types.

---

#### 4.2.1. Time RMS Error

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Measurement of time can be significant in certain circumstances. The GNSS measurements included in this document are one such case where a small error in time can result in a large error in location. Factors such as clock drift and errors in time synchronization can result in small, but significant, time errors. Including an indication of the quality of the time can be helpful.

An optional `timeError` attribute can be added to the measurement element to indicate the RMS error in time. `timeError` indicates an upper bound on the time RMS error in seconds.

The `timeError` attribute does not apply where multiple samples of a measurement is taken over time. If multiple samples are taken, each SHOULD be included in a different measurement element.

---

#### 4.3. Measurement Request

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A measurement request is used by a protocol peer to describe a set of measurement data that it desires. A `measurementRequest` element is defined that can be included in a protocol exchange.

For instance, a LIS can use a measurement request in HELD responses. If the LIS is unable to provide location information, but it believes that a particular measurement type would enable it to provide a location, it can include a measurement request in an error response.

The measurement element of the measurement request identifies the type of measurement that is requested. The `type` attribute of this element

indicates the type of measurement, as identified by an XML qualified name. An optional samples attribute indicates how many samples of the identified measurement are requested.

The measurement element can be repeated to request multiple (or alternative) measurement types.

Additional XML content might be defined for a particular measurement type that is used to further refine a request. These elements either constrain what is requested or specify optional components of the measurement data that are needed. These are defined along with the specific measurement type.

In the HELD protocol, the inclusion of a measurement request in a error response with a code of locationUnknown indicates that the LIS believes that providing the indicated measurements would increase the likelihood of a subsequent request being successful.

---

The following example shows a HELD error response that indicates that WiFi measurement data would be useful if a later request were made. Additional elements indicate that received signal strength for an 802.11n access point is requested.

```
<error xmlns="urn:ietf:params:xml:ns:geopriv:held"
      code="locationUnknown">
  <message xml:lang="en">Insufficient measurement data</message>
  <measurementRequest
    xmlns="urn:ietf:params:xml:ns:geopriv:lm"
    xmlns:wifi="urn:ietf:params:xml:ns:geopriv:lm:wifi">
    <measurement type="wifi:wifi">
      <wifi:type>n</wifi:type>
      <wifi:parameters>wifi:rssi</wifi:parameters>
    </measurement>
  </measurementRequest>
</error>
```

**Figure 3**

---

A measurement request that is included in other HELD messages has undefined semantics and can be safely ignored. Other specifications might define semantics for measurement requests under other conditions.

---

#### 4.4. Identifying Location Provenance

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An extension is made to the [PIDF-LO \(Peterson, J., "A Presence-based GEOPRIV Location Object Format," December 2005.\)](#) [RFC4119] that allows

a location recipient to identify the source (or sources) of location information and the measurement data that was used to determine that location information.

The source element is added to the geopriv element of the PIDF-LO. This element does not identify specific entities. Instead, it identifies the type of source.

The following types of measurement source are identified:

**lis:** Location information is based on measurement data that the LIS or sources that it trusts have acquired. This label might be used if measurement data provided by the Device has been completely validated by the LIS.

**device:** Location information is based on measurement data that the Device has provided to the LIS.

**other:** Location information is based on measurement data that a third party has provided. This might be an authorized third party that uses [identity parameters \(Winterbottom, J., Thomson, M., Tschofenig, H., and R. Barnes, "Use of Device Identity in HTTP-Enabled Location Delivery \(HELD\)," February 2010.\)](#) [I-D.ietf-geopriv-held-identity-extensions] or any other entity.

No assertion is made about the veracity of the measurement data from sources other than the LIS. A combination of tags MAY be included to indicate that measurement data from both sources was used.

For example, the first tuple of the following PIDF-LO indicates that measurement data from a LIS and a device was combined to produce the result, the second tuple was produced by the LIS alone.

```

<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  xmlns:lmsrc="urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc"
  entity="pres:lm@example.com">
  <tuple id="deviceLoc">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Circle srsName="urn:ogc:def:crs:EPSG::4326">
            <gml:pos>7.34324 134.47162</gml:pos>
            <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
              850.24
            </gs:radius>
          </gs:Circle>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>OTDOA</gp:method>
        <lmsrc:source>lis device</lmsrc:source>
      </gp:geopriv>
    </status>
  </tuple>
  <tuple id="lisLoc">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Circle srsName="urn:ogc:def:crs:EPSG::4326">
            <gml:pos>7.34379 134.46484</gml:pos>
            <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
              9000
            </gs:radius>
          </gs:Circle>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Cell</gp:method>
        <lmsrc:source>lis</lmsrc:source>
      </gp:geopriv>
    </status>
  </tuple>
</presence>

```

## 5. Location-Related Measurement Data Types

This document defines location-related measurement data types for a range of common network types.

---

### 5.1. LLDP Measurements

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LLDP messages are sent between adjacent nodes in an IEEE 802 network (e.g. wired Ethernet, WiFi, 802.16). These messages all contain identification information for the sending node, which can be used to determine location information. A Device that receives LLDP messages can report this information as a location-related measurement to the LIS, which is then able to use the measurement data in determining the location of the Device.

The Device **MUST** report the values directly as they were provided by the adjacent node. Attempting to adjust or translate the type of identifier is likely to cause the measurement data to be useless.

Where a Device has received LLDP messages from multiple adjacent nodes, it should provide information extracted from those messages by repeating the lldp element.

An example of an LLDP measurement is shown in [Figure 4 \(LLDP Measurement Example\)](#). This shows an adjacent node (chassis) that is identified by the IP address 192.0.2.45 (hexadecimal c000022d) and the port on that node is numbered using an [agent circuit ID \(Patrick, M., "DHCP Relay Agent Information Option," January 2001.\)](#) [RFC3046] of 162 (hexadecimal a2).

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <lldp xmlns="urn:ietf:params:xml:ns:geopriv:lm:lldp">
    <chassis type="4">c000022d</chassis>
    <port type="6">a2</port>
  </lldp>
</measurements>
```

**Figure 4: LLDP Measurement Example**

---

IEEE 802 Devices that are able to obtain information about adjacent network switches and their attachment to them by other means MAY use this data type to convey this information.

---

## 5.2. DHCP Relay Agent Information Measurements

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The [DHCP Relay Agent Information option](#) (Patrick, M., "DHCP Relay Agent Information Option," January 2001.) [RFC3046] provides measurement data about the network attachment of a Device. This measurement data can be included in the dhcp-rai element.

The elements in the DHCP relay agent information options are opaque data types assigned by the DHCP relay agent. The three items are all optional: circuit identifier (circuit, [RFC3046] (Patrick, M., "DHCP Relay Agent Information Option," January 2001.)), remote identifier (remote, [RFC3046] (Patrick, M., "DHCP Relay Agent Information Option," January 2001.), [RFC4649] (Volz, B., "Dynamic Host Configuration Protocol for IPv6 (DHCPv6) Relay Agent Remote-ID Option," August 2006.)) and subscriber identifier (subscriber, [RFC3993] (Johnson, R., Palaniappan, T., and M. Stapp, "Subscriber-ID Suboption for the Dynamic Host Configuration Protocol (DHCP) Relay Agent Option," March 2005.), [RFC4580] (Volz, B., "Dynamic Host Configuration Protocol for IPv6 (DHCPv6) Relay Agent Subscriber-ID Option," June 2006.)). The DHCPv6 remote identifier has an associated [enterprise number](#) (IANA, "Private Enterprise Numbers," .) [IANA.enterprise] as an XML attribute.

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
    time="2008-04-29T14:33:58">
  <dhcp-rai xmlns="urn:ietf:params:xml:ns:geopriv:lm:dhcp">
    <giaddr>::ffff:192.0.2.158</giaddr>
    <circuit>108b</circuit>
  </dhcp-rai>
</measurements>
```

**Figure 5: DHCP Relay Agent Information Measurement Example**

---

The giaddr is specified as a dotted quad IPv4 address or an [RFC 4291](#) (Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture," February 2006.) [RFC4291] IPv6 address. The enterprise number is specified as a decimal integer. All other information is included verbatim from the DHCP request in hexadecimal format.

---

## 5.3. 802.11 WLAN Measurements

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In WiFi, or 802.11, networks a Device might be able to provide information about the wireless access point (WAP) that it is attached

to, or other WiFi points it is able to see. This is provided using the wifi element, as shown in [Figure 6 \(802.11 WLAN Measurement Example\)](#).

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <wifi xmlns="urn:ietf:params:xml:ns:geopriv:lm:wifi">
    <nicType>Example WiFi Device</nicType>
    <servingWap>
      <ssid>wlan-home</ssid>
      <bssid>00-12-F0-A0-80-EF</bssid>
      <channel>7</channel>
      <rssi>-55</rssi>
    </servingWap>
    <neighbourWap>
      <ssid>wlan-home</ssid>
      <bssid>00-12-F0-A0-80-F0</bssid>
      <rssi>-65</rssi>
    </neighbourWap>
    <neighbourWap>
      <ssid>vendordefault</ssid>
      <bssid>00-12-F0-A0-80-F1</bssid>
      <rssi>-68</rssi>
    </neighbourWap>
    <neighbourWap>
      <ssid>ironicname</ssid>
      <bssid>00-12-F0-A0-80-F2</bssid>
      <rssi>-75</rssi>
    </neighbourWap>
  </wifi>
</measurements>
```

**Figure 6: 802.11 WLAN Measurement Example**

---

A wifi element is made up of a serving WAP, zero or more neighbouring WAPs, and an optional nicType element. Each WAP element is comprised of the following fields:

**ssid:**

The service set identifier for the wireless network. This parameter MAY be provided.

**bssid:** The basic service set identifier. In an Infrastructure BSS network, the bssid is the 48 bit MAC address of the wireless access point, and it MUST be provided.

**wapname:** The broadcast name for the wireless access point. This element is optional.

**location:** The location of the wireless access point, as reported using by the wireless access point. This optional element contains GML geometry, following the restrictions described in [\[RFC5491\] \(Winterbottom, J., Thomson, M., and H. Tschofenig, "GEOPRIV Presence Information Data Format Location Object \(PIDF-LO\) Usage Clarification, Considerations, and Recommendations," March 2009.\)](#).

**type:** The network type for the network access. This element includes the alphabetic suffix of the 802.11 specification that defines the radio interface; e.g. a, b, g, or n. This element is optional.

**channel:** The channel number (frequency) that the wireless access point operates on. This element is optional.

**rssi:** The received signal strength indicator of the WAP as seen by the wireless receiver. This value SHOULD be in units of dBm (with RMS error in dB). If the units are unknown, the dBm attribute MUST be set to false. Signal strength reporting on current hardware uses a range of different units; therefore, the value of the nicType element SHOULD be included if the units are not known to be in dBm and the value reported by the hardware should be included without modification. This element is optional and includes optional rmsError and samples attributes.

**snr:** The signal to noise ratio measured by the Device, in dBm. This element is optional and includes optional rmsError and samples attributes.

**rtt:** The total round trip time from the time that a request is sent by the Device to the time that it receives the response from the access point. This measurement includes any delays that might occur between the time that the access point receives the message and the time that it sends the response. If the delay at an access point is known, this value can be used to calculate an approximate distance between device and access point. This element is optional and includes optional rmsError and samples attributes.



The `nicType` element is used to specify the make and model of the wireless network interface in the Device. Different 802.11 chipsets report the signal strength in different ways, so the network interface type must be specified in order for the LIS to use signal strength indicators as part of its location determination process. The content of this field is unconstrained and no mechanisms are specified to ensure uniqueness.

---

### 5.3.1. Wifi Measurement Requests

[TOC](#)

Two elements are defined for requesting WiFi measurements in a measurement request:

**type:** The type element identifies the desired type (or types that are requested).

**parameter:** The parameter element identifies an optional measurements are requested for each measured access point. An element is identified by its qualified name.

Multiple types or parameters can be requested by repeating either element.

---

### 5.4. Cellular Measurements

[TOC](#)

Cellular Devices are common throughout the world and base station identifiers can provide a good source of coarse location information. This information can be provided to a LIS run by the cellular operator, or may be provided to an alternative LIS operator that has access to one of several global cell-id to location mapping databases. A number of advanced location determination methods have been developed for cellular networks. For these methods a range of measurement parameters can be collected by the network, Device, or both in cooperation. This document includes a basic identifier for the wireless transmitter only; future efforts might define additional parameters that enable more accurate methods of location determination. The cellular measurement set allows a Device to report to a LIS any LTE ([Figure 7 \(Example LTE Cellular Measurement\)](#)), UMTS ([Figure 8 \(Example UMTS Cellular Measurement\)](#)), GSM ([Figure 9 \(Example GSM Cellular Measurement\)](#)) or CDMA ([Figure 10 \(Example CDMA Cellular Measurement\)](#)) cells that it is able to observe. Cells are reported using their global identifiers. All 3GPP cells are identified by public land mobile network (PLMN), which is formed of mobile country code (MCC) and mobile

network code (MNC); specific fields are added for each network type. All other values are decimal integers.

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <cellular xmlns="urn:ietf:params:xml:ns:geopriv:lm:cell">
    <servingCell>
      <mcc>465</mcc><mnc>20</mnc>
      <eucid>80936424</eucid>
    </servingCell>
    <observedCell>
      <mcc>465</mcc><mnc>06</mnc>
      <eucid>10736789</eucid>
    </observedCell>
  </cellular>
</measurements>
```

Long term evolution (LTE) cells are identified by a 28-bit cell identifier (eucid).

**Figure 7: Example LTE Cellular Measurement**

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <cellular xmlns="urn:ietf:params:xml:ns:geopriv:lm:cell">
    <servingCell>
      <mcc>465</mcc><mnc>20</mnc>
      <rnc>2000</rnc><cid>65000</cid>
    </servingCell>
    <observedCell>
      <mcc>465</mcc><mnc>06</mnc>
      <lac>16383</lac><cid>32767</cid>
    </observedCell>
  </cellular>
</measurements>
```

Universal mobile telephony service (UMTS) cells are identified by radio network controller (rnc) and cell id (cid).

**Figure 8: Example UMTS Cellular Measurement**

---

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <cellular xmlns="urn:ietf:params:xml:ns:geopriv:lm:cell">
    <servingCell>
      <mcc>465</mcc><mnc>06</mnc>
      <lac>16383</lac><cid>32767</cid>
    </servingCell>
  </cellular>
</measurements>
```

Groupe Speciale Mobile (GSM) cells are identified by local radio network controller (rnc) and cell id (cid).

**Figure 9: Example GSM Cellular Measurement**

---

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <cellular xmlns="urn:ietf:params:xml:ns:geopriv:lm:cell">
    <servingCell>
      <nid>4723</nid><sid>15892</sid><baseid>12</baseid>
    </servingCell>
    <observedCell>
      <nid>4723</nid><sid>15892</sid><baseid>13</baseid>
    </observedCell>
  </cellular>
</measurements>
```

Code division multiple access (CDMA) cells are not identified by PLMN, instead these use network id (nid), system id (sid) and base station id (baseid).

**Figure 10: Example CDMA Cellular Measurement**

---

In general a cellular Device will be attached to the cellular network and so the notion of a serving cell exists. Cellular network also provide overlap between neighbouring sites, so a mobile Device can hear more than one cell. The measurement schema supports sending both the serving cell and any other cells that the mobile might be able to hear. In some cases, the Device may simply be listening to cell information without actually attaching to the network, mobiles without a SIM are an

example of this. In this case the Device may simply report cells it can hear without flagging one as a serving cell. An example of this is shown in [Figure 11 \(Example Observed Cellular Measurement\)](#).

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <cellular xmlns="urn:ietf:params:xml:ns:geopriv:lm:cell">
    <observedCell>
      <mcc>465</mcc><mnc>20</mnc>
      <rnc>2000</rnc><cid>65000</cid>
    </observedCell>
    <observedCell>
      <mcc>465</mcc><mnc>06</mnc>
      <lac>16383</lac><cid>32767</cid>
    </observedCell>
  </cellular>
</measurements>
```

**Figure 11: Example Observed Cellular Measurement**

---

#### 5.4.1. Cellular Measurement Requests

[TOC](#)

Two elements can be used in measurement requests for cellular measurements:

**type:** A label indicating the type of identifier to provide: one of gsm, umts, lte, or cdma.

**network:** The network portion of the cell identifier. For 3GPP networks, this is the combination of MCC and MNC; for CDMA, this is the network identifier.

Multiple identifier types or networks can be identified by repeating either element.

---

#### 5.5. GNSS Measurements

[TOC](#)

GNSS use orbiting satellites to transmit signals. A Device with a GNSS receiver is able to take measurements from the satellite signals. The

results of these measurements can be used to determine time and the location of the Device.

Determining location and time in autonomous GNSS receivers follows three steps:

**Signal acquisition:** During the signal acquisition stage, the receiver searches for the repeating code that is sent by each GNSS satellite. Successful operation typically requires measurement data for a minimum of 5 satellites. At this stage, measurement data is available to the Device.

**Navigation message decode:** Once the signal has been acquired, the receiver then receives information about the configuration of the satellite constellation. This information is broadcast by each satellite and is modulated with the base signal at a low rate; for instance, GPS sends this information at about 50 bits per second.

**Calculation:** The measurement data is combined with the data on the satellite constellation to determine the location of the receiver and the current time.

A Device that uses a GNSS receiver is able to report measurements after the first stage of this process. A LIS can use the results of these measurements to determine a location. In the case where there are fewer results available than the optimal minimum, the LIS might be able to use other sources of measurement information and combine these with the available measurement data to determine a position.

Note: The use of different sets of GNSS *assistance data* can reduce the amount of time required for the signal acquisition stage and obviate the need for the receiver to extract data on the satellite constellation. Provision of assistance data is outside the scope of this document.

[Figure 12 \(Example GNSS Measurement\)](#) shows an example of GNSS measurement data. The measurement shown is for the GPS system and includes measurement data for three satellites only.

---

```

<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
               time="2008-04-29T14:33:58" timeError="2e-5">
  <gnss xmlns="urn:ietf:params:xml:ns:geopriv:lm:gnss"
        system="gps" signal="L1">
    <sat num="19">
      <doppler>499.9395</doppler>
      <codephase rmsError="1.6e-9">0.87595747</codephase>
      <cn0>45</cn0>
    </sat>
    <sat num="27">
      <doppler>378.2657</doppler>
      <codephase rmsError="1.6e-9">0.56639479</codephase>
      <cn0>52</cn0>
    </sat>
    <sat num="20">
      <doppler>-633.0309</doppler>
      <codephase rmsError="1.6e-9">0.57016835</codephase>
      <cn0>48</cn0>
    </sat>
  </gnss>
</measurements>

```

**Figure 12: Example GNSS Measurement**

Each gnss element represents a single set of GNSS measurement data, taken at a single point in time. Measurements taken at different times can be included in different gnss elements to enable iterative refinement of results.

GNSS measurement parameters are described in more detail in the following sections.

#### 5.5.1. GNSS System and Signal

[TOC](#)

The GNSS measurement structure is designed to be generic and to apply to different GNSS types. Different signals within those systems are also accounted for and can be measured separately.

The GNSS type determines the time system that is used. An indication of the type of system and signal can ensure that the LIS is able to correctly use measurements.

Measurements for multiple GNSS types and signals can be included by repeating the gnss element.

This document creates an IANA registry for GNSS types. Two satellite systems are registered by this document: GPS and Galileo. Details for

the registry are included in [Section 9.1 \(IANA Registry for GNSS Types\)](#).

---

#### 5.5.2. Time

[TOC](#)

Each set of GNSS measurements is taken at a specific point in time. The time attribute is used to indicate the time that the measurement was acquired, if the receiver knows how the time system used by the GNSS relates to UTC time.

Alternative to (or in addition to) the measurement time, the `gnssTime` element MAY be included. The `gnssTime` element includes a relative time in milliseconds using the time system native to the satellite system. For the GPS satellite system, the `gnssTime` element includes the time of week in milliseconds. For the Galileo system, the `gnssTime` element includes the time of day in milliseconds.

The accuracy of the time measurement provided is critical in determining the accuracy of the location information derived from GNSS measurements. The receiver SHOULD indicate an estimated time error for any time that is provided. An RMS error can be included for the `gnssTime` element, with a value in milliseconds.

---

#### 5.5.3. Per-Satellite Measurement Data

[TOC](#)

Multiple satellites are included in each set of GNSS measurements using the `sat` element. Each satellite is identified by a number in the `num` attribute. The satellite number is consistent with the identifier used in the given GNSS.

Both the GPS and Galileo systems use satellite numbers between 1 and 64.

The GNSS receiver measures the following parameters for each satellite:

**doppler:** The observed Doppler shift of the satellite signal, measured in meters per second. This is converted from a value in Hertz by the receiver to allow the measurement to be used without knowledge of the carrier frequency of the satellite system. This value includes an optional RMS error attribute, also measured in meters per second.

**codephase:** The observed code phase for the satellite signal, measured in milliseconds. This is converted from a value in chips or wavelengths. Increasing values indicate increasing pseudoranges. This value includes an optional RMS error attribute, also measured in milliseconds.

**cn0:**

The signal to noise ratio for the satellite signal, measured in decibel-Hertz (dB-Hz). The expected range is between 20 and 50 dB-Hz.

**mp:** An estimation of the amount of error that multipath signals contribute in metres. This parameter is optional.

**cq:** An indication of the carrier quality. Two attributes are included: continuous may be either true or false; direct may be either direct or inverted. This parameter is optional.

**adr:** The accumulated Doppler range, measured in metres. This parameter is optional and is not necessary unless multiple sets of GNSS measurements are provided.

All values are converted from measures native to the satellite system to generic measures to ensure consistency of interpretation. Unless necessary, the schema does not constrain these values.

---

#### 5.5.4. GNSS Measurement Requests

[TOC](#)

Measurement requests can include a gnss element, which includes the system and signal attributes. Multiple elements can be included to indicate a requests for GNSS measurements from multiple systems or signals.

---

#### 5.6. DSL Measurements

[TOC](#)

Digital Subscriber Line (DSL) networks rely on a range of network technology. DSL deployments regularly require cooperation between multiple organizations. These fall into two broad categories: infrastructure providers and Internet service providers (ISPs). Infrastructure providers manage the bulk of the physical infrastructure including cabling. End users obtain their service from an ISP, which manages all aspects visible to the end user including IP address allocation and operation of a LIS. See [\[DSL.TR025\] \(Wang, R., "Core Network Architecture Recommendations for Access to Legacy Data Networks over ADSL," September 1999.\)](#) and [\[DSL.TR101\] \(Cohen, A. and E. Shrum, "Migration to Ethernet-Based DSL Aggregation," April 2006.\)](#) for further information on DSL network deployments.

Exchange of measurement information between these organizations is necessary for location information to be correctly generated. The ISP LIS needs to acquire location information from the infrastructure



provider. However, the infrastructure provider has no knowledge of Device identifiers, it can only identify a stream of data that is sent to the ISP. This is resolved by passing measurement data relating to the Device to a LIS operated by the infrastructure provider.

---

#### 5.6.1. L2TP Measurements

[TOC](#)

Layer 2 Tunneling Protocol (L2TP) is a common means of linking the infrastructure provider and the ISP. The infrastructure provider LIS requires measurement data that identifies a single L2TP tunnel, from which it can generate location information. [Figure 13 \(Example DSL L2TP Measurement\)](#) shows an example L2TP measurement.

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
    time="2008-04-29T14:33:58">
  <dsl xmlns="urn:ietf:params:xml:ns:geopriv:lm:dsl">
    <l2tp>
      <src>192.0.2.10</src>
      <dest>192.0.2.61</dest>
      <session>528</session>
    </l2tp>
  </dsl>
</measurements>
```

**Figure 13: Example DSL L2TP Measurement**

---

#### 5.6.2. RADIUS Measurements

[TOC](#)

When authenticating network access, the infrastructure provider might employ a [RADIUS \(Rigney, C., Willens, S., Rubens, A., and W. Simpson, "Remote Authentication Dial In User Service \(RADIUS\)," June 2000.\)](#) [RFC2865] proxy at the DSL Access Module (DSLAM) or Access Node (AN). These messages provide the ISP RADIUS server with an identifier for the DSLAM or AN, plus the slot and port that the Device is attached on. These data can be provided as a measurement, which allows the infrastructure provider LIS to generate location information. The format of the AN, slot and port identifiers are not defined in the RADIUS protocol. Slot and port together identify a circuit on the AN,

analogous to the circuit identifier in [\[RFC3046\] \(Patrick, M., "DHCP Relay Agent Information Option," January 2001.\)](#). These items are provided directly, as they were in the RADIUS message. An example is shown in [Figure 14 \(Example DSL RADIUS Measurement\)](#).

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <dsl xmlns="urn:ietf:params:xml:ns:geopriv:lm:dsl">
    <an>AN-7692</an>
    <slot>3</slot>
    <port>06</port>
  </dsl>
</measurements>
```

**Figure 14: Example DSL RADIUS Measurement**

---

### 5.6.3. Ethernet VLAN Tag Measurements

[TOC](#)

For Ethernet-based DSL access networks, the DSL Access Module (DSLAM) or Access Node (AN) provide two VLAN tags on packets. A C-TAG is used to identify the incoming residential circuit, while the S-TAG is used to identify the DSLAM or AN. The C-TAG and S-TAG together can be used to identify a single point of network attachment. An example is shown in [Figure 15 \(Example DSL VLAN Tag Measurement\)](#).

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
  time="2008-04-29T14:33:58">
  <dsl xmlns="urn:ietf:params:xml:ns:geopriv:lm:dsl">
    <stag>613</stag>
    <ctag>1097</ctag>
  </dsl>
</measurements>
```

**Figure 15: Example DSL VLAN Tag Measurement**

---

Alternatively, the C-TAG can be replaced by data on the slot and port that the Device is attached to. This information might be included in

RADIUS requests that are proxied from the infrastructure provider to the ISP RADIUS server.

---

#### 5.6.4. ATM Virtual Circuit Measurements

[TOC](#)

An ATM virtual circuit can be employed between the ISP and infrastructure provider. Providing the virtual port ID (VPI) and virtual circuit ID (VCI) for the virtual circuit gives the infrastructure provider LIS the ability to identify a single data stream. A sample measurement is shown in [Figure 16 \(Example DSL ATM Measurement\)](#).

---

```
<measurements xmlns="urn:ietf:params:xml:ns:geopriv:lm"
    time="2008-04-29T14:33:58">
  <dsl xmlns="urn:ietf:params:xml:ns:geopriv:lm:dsl">
    <vpi>55</vpi>
    <vci>6323</vci>
  </dsl>
</measurements>
```

**Figure 16: Example DSL ATM Measurement**

---

## 6. Measurement Schemas

[TOC](#)

The schema are broken up into their respective functions. There is a base container schema into which all measurements are placed, plus definitions for a measurement request ([Section 6.1 \(Measurement Container Schema\)](#)). A PIDF-LO extension is defined in a separate schema ([Section 6.2 \(Measurement Source Schema\)](#)). There is a basic types schema, that contains various base type definitions for things such as the rmsError and samples attributes IPv4, IPv6 and MAC addresses ([Section 6.3 \(Base Type Schema\)](#)). Then each of the specific measurement types is defined in its own schema.

---

[TOC](#)

## 6.1. Measurement Container Schema

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:lm="urn:ietf:params:xml:ns:geopriv:lm"
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:schema:geopriv:lm">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a framework for location measurements.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"/>

  <xs:element name="measurements">
    <xs:complexType>
      <xs:complexContent>
        <xs:restriction base="xs:anyType">
          <xs:sequence>
            <xs:any namespace="##other" processContents="lax"
              minOccurs="0" maxOccurs="unbounded"/>
          </xs:sequence>
          <xs:attribute name="time" type="xs:dateTime"/>
          <xs:attribute name="timeError" type="bt:positiveDouble"/>
          <xs:attribute name="expires" type="xs:dateTime"/>
          <xs:anyAttribute namespace="##any" processContents="lax"/>
        </xs:restriction>
      </xs:complexContent>
    </xs:complexType>
  </xs:element>

  <xs:element name="measurementRequest"
    type="lm:measurementRequestType"/>
  <xs:complexType name="measurementRequestType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="measurement" type="lm:measurementType"
            minOccurs="0" maxOccurs="unbounded"/>
          <xs:any namespace="##other" processContents="lax"

```

```
        minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
</xs:restriction>
</xs:complexContent>
</xs:complexType>

<xs:complexType name="measurementType">
  <xs:complexContent>
    <xs:restriction base="xs:anyType">
      <xs:sequence>
        <xs:any namespace="##other" processContents="lax"
          minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="type" type="xs:QName" use="required"/>
      <xs:attribute name="samples" type="xs:positiveInteger"/>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>
```

---

### Measurement Container Schema

---

## 6.2. Measurement Source Schema

[TOC](#)

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:lmsrc="urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:schema:pidf:geopriv10:lmsrc">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines an extension to PIDF-LO that indicates the
      type of source that produced the measurement data used in
      generating the associated location information.
    </xs:documentation>
  </xs:annotation>

  <xs:element name="source" type="lmsrc:sourceType"/>
  <xs:simpleType name="sourceType">
    <xs:list>
      <xs:simpleType>
        <xs:restriction base="xs:token">
          <xs:enumeration value="lis"/>
          <xs:enumeration value="device"/>
          <xs:enumeration value="other"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:list>
  </xs:simpleType>
</xs:schema>

```

---

### Measurement Source PIDF-LO Extension Schema

---

#### 6.3. Base Type Schema

[TOC](#)

Note that the pattern rules in the following schema wrap due to length constraints. None of the patterns contain whitespace.

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:schema:geopriv:lm:basetypes">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a set of base type elements.
    </xs:documentation>
  </xs:annotation>

  <xs:simpleType name="byteType">
    <xs:restriction base="xs:integer">
      <xs:minInclusive value="0"/>
      <xs:maxInclusive value="255"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="twoByteType">
    <xs:restriction base="xs:integer">
      <xs:minInclusive value="0"/>
      <xs:maxInclusive value="65535"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="nonNegativeDouble">
    <xs:restriction base="xs:double">
      <xs:minInclusive value="0.0"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="positiveDouble">
    <xs:restriction base="bt:nonNegativeDouble">
      <xs:minExclusive value="0.0"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:complexType name="doubleWithRMSError">
    <xs:simpleContent>
      <xs:extension base="xs:double">
        <xs:attribute name="rmsError" type="bt:positiveDouble"/>
        <xs:attribute name="samples" type="xs:positiveInteger"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>

```



```

        </xs:extension>
    </xs:simpleContent>
</xs:complexType>
<xs:complexType name="nnDoubleWithRMSError">
    <xs:simpleContent>
        <xs:restriction base="bt:doubleWithRMSError">
            <xs:minInclusive value="0"/>
        </xs:restriction>
    </xs:simpleContent>
</xs:complexType>

<xs:simpleType name="ipAddressType">
    <xs:union memberTypes="bt:IPv6AddressType bt:IPv4AddressType"/>
</xs:simpleType>

<!-- IPv6 format definition -->
<xs:simpleType name="IPv6AddressType">
    <xs:annotation>
        <xs:documentation>
            An IP version 6 address, based on RFC 4291.
        </xs:documentation>
    </xs:annotation>
    <xs:restriction base="xs:token">
        <!-- Fully specified address -->
        <xs:pattern value="[0-9A-Fa-f]{1,4}(:[0-9A-Fa-f]{1,4}){7}" />
        <!-- Double colon start -->
        <xs:pattern value="(:[0-9A-Fa-f]{1,4}){1,7}" />
        <!-- Double colon middle -->
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1,6}
            (:[0-9A-Fa-f]{1,4}){1}" />
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1,5}
            (:[0-9A-Fa-f]{1,4}){1,2}" />
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1,4}
            (:[0-9A-Fa-f]{1,4}){1,3}" />
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1,3}
            (:[0-9A-Fa-f]{1,4}){1,4}" />
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1,2}
            (:[0-9A-Fa-f]{1,4}){1,5}" />
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1}
            (:[0-9A-Fa-f]{1,4}){1,6}" />
        <!-- Double colon end -->
        <xs:pattern value="([0-9A-Fa-f]{1,4}:){1,7}" />
        <!-- IPv4-Compatible and IPv4-Mapped Addresses -->
        <xs:pattern value="((:0{1,4}){0,3}:[fF]{4})|((0{1,4}):
            (:0{1,4}){0,2}:[fF]{4})|((0{1,4}:){2}
            (:0{1,4})?:[fF]{4})|((0{1,4}:){3}:[fF]{4})
            |((0{1,4}:){4}[fF]{4})):(25[0-5]|2[0-4][0-9]|
            [0-1]?[0-9]?[0-9])\. (25[0-5]|2[0-4][0-9]| [0-1]?
            ?[0-9]?[0-9])\. (25[0-5]|2[0-4][0-9]| [0-1]?

```

```

                [0-9]?[0-9])\.(25[0-5]|2[0-4][0-9]|[0-1]?
                [0-9]?[0-9])"/>
        <!-- The unspecified address -->
        <xs:pattern value="::"/>
    </xs:restriction>
</xs:simpleType>

<!-- IPv4 format definition -->
<xs:simpleType name="IPv4AddressType">
    <xs:restriction base="xs:token">
        <xs:pattern value="(25[0-5]|2[0-4][0-9]|[0-1]?[0-9]?[0-9])\.
                (25[0-5]|2[0-4][0-9]|[0-1]?[0-9]?[0-9])\.
                (25[0-5]|2[0-4][0-9]|[0-1]?[0-9]?[0-9])\.
                (25[0-5]|2[0-4][0-9]|[0-1]?[0-9]?[0-9])"/>
    </xs:restriction>
</xs:simpleType>

<!-- IEEE specifies a MAC address as having a -
        between 2 hex digit pairs -->
<xs:simpleType name="macAddressType">
    <xs:restriction base="xs:token">
        <xs:pattern value="([0-9A-Fa-f]{2}-){5}([0-9A-Fa-f]{2})"/>
    </xs:restriction>
</xs:simpleType>

</xs:schema>

```

---

### Base Type Schema

---

## 6.4. LLDP Measurement Schema

[TOC](#)

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:lldp="urn:ietf:params:xml:ns:geopriv:lm:lldp"
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:lldp"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:ns:geopriv:lm:lldp">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a set of LLDP location measurements.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"/>

  <xs:element name="lldp" type="lldp:lldpMeasurementType"/>
  <xs:complexType name="lldpMeasurementType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="chassis" type="lldp:lldpDataType"/>
          <xs:element name="port" type="lldp:lldpDataType"/>
          <xs:any namespace="##other" processContents="lax"
            minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:anyAttribute namespace="##any" processContents="lax"/>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="lldpDataType">
    <xs:simpleContent>
      <xs:extension base="lldp:lldpOctetStringType">
        <xs:attribute name="type" type="bt:byteType"
          use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>

  <xs:simpleType name="lldpOctetStringType">
    <xs:restriction base="xs:hexBinary">

```

```
        <xs:minLength value="1"/>
        <xs:maxLength value="255"/>
    </xs:restriction>
</xs:simpleType>

</xs:schema>
```

---

<b>LLDP measurement schema</b>
--------------------------------

---

---

## 6.5. DHCP Measurement Schema

<a href="#">TOC</a>
---------------------

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:dhcp="urn:ietf:params:xml:ns:geopriv:lm:dhcp"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:dhcp"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:ns:geopriv:lm:dhcp">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a set of DHCP location measurements.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"/>

  <!-- DHCP Relay Agent Information Option -->
  <xs:element name="dhcp-rai" type="dhcp:dhcpType"/>
  <xs:complexType name="dhcpType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="giaddr" type="bt:ipAddressType"/>
          <xs:element name="circuit"
            type="xs:hexBinary" minOccurs="0"/>
          <xs:element name="remote"
            type="dhcp:dhcpRemoteType" minOccurs="0"/>
          <xs:element name="subscriber"
            type="xs:hexBinary" minOccurs="0"/>
          <xs:any namespace="##other" processContents="lax"
            minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:anyAttribute namespace="##any" processContents="lax"/>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="dhcpRemoteType">
    <xs:simpleContent>
      <xs:extension base="xs:hexBinary">
        <xs:attribute name="enterprise" type="xs:positiveInteger"
          use="optional"/>

```

```
        </xs:extension>
      </xs:simpleContent>
    </xs:complexType>

</xs:schema>
```

---

<b>DHCP measurement schema</b>
--------------------------------

---

---

## 6.6. WiFi Measurement Schema

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---------------------

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:wifi="urn:ietf:params:xml:ns:geopriv:lm:wifi"
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:wifi"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:schema:geopriv:lm:wifi">
      WiFi location measurements
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a basic set of WiFi location measurements.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"/>
  <xs:import namespace="http://www.opengis.net/gml"/>

  <xs:element name="wifi" type="wifi:wifiNetworkType"/>

  <xs:complexType name="wifiNetworkType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="nicType" type="xs:token"
            minOccurs="0"/>
          <xs:choice>
            <xs:element name="servingWap" type="wifi:wifiType"/>
            <xs:element name="neighbourWap" type="wifi:wifiType"/>
          </xs:choice>
          <xs:element name="neighbourWap" type="wifi:wifiType"
            minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:anyAttribute namespace="##any" processContents="lax"/>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="wifiType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">

```

```

<xs:sequence>
  <xs:element name="ssid" type="wifi:ssidBaseType"
    minOccurs="0"/>
  <xs:element name="bssid" type="bt:macAddressType"/>
  <xs:element name="wapname" type="wifi:ssidBaseType"
    minOccurs="0"/>
  <xs:element name="location" minOccurs="0"
    type="gml:GeometryPropertyType"/>
  <xs:element name="type" type="wifi:networkType"
    minOccurs="0"/>
  <xs:element name="channel" type="xs:nonNegativeInteger"
    minOccurs="0"/>
  <xs:element name="rssi" type="wifi:rssiType"
    minOccurs="0"/>
  <xs:element name="snr" type="bt:doubleWithRMSError"
    minOccurs="0"/>
  <xs:element name="rtt" type="bt:doubleWithRMSError"
    minOccurs="0"/>
  <xs:any namespace="##other" processContents="lax"
    minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:anyAttribute namespace="##any" processContents="lax"/>
</xs:restriction>
</xs:complexContent>
</xs:complexType>

<xs:simpleType name="ssidBaseType">
  <xs:restriction base="xs:token">
    <xs:maxLength value="32"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="networkType">
  <xs:restriction base="xs:token">
    <xs:pattern value="[a-zA-Z]+" />
  </xs:restriction>
</xs:simpleType>

<xs:complexType name="rssiType">
  <xs:simpleContent>
    <xs:extension base="bt:doubleWithRMSError">
      <xs:attribute name="dBm" type="xs:boolean" default="true"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>

<!-- Measurement Request elements -->
<xs:element name="type" type="wifi:networkType"/>
<xs:element name="parameter" type="xs:QName"/>

```



</xs:schema>

WiFi measurement schema

---

6.7. Cellular Measurement Schema

[TOC](#)

---

```

<?xml version="1.0"?>
<xs:schema
  xmlns:cell="urn:ietf:params:xml:ns:geopriv:lm:cell"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:cell"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:schema:geopriv:lm:cell">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a set of cellular location measurements.
    </xs:documentation>
  </xs:annotation>

  <xs:element name="cellular" type="cell:cellularType"/>

  <xs:complexType name="cellularType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:choice>
            <xs:element name="servingCell" type="cell:cellType"/>
            <xs:element name="observedCell" type="cell:cellType"/>
          </xs:choice>
          <xs:element name="observedCell" type="cell:cellType"
            minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:anyAttribute namespace="##any" processContents="lax"/>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="cellType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:choice>
          <xs:sequence>
            <xs:element name="mcc" type="cell:mccType"/>
            <xs:element name="mnc" type="cell:mncType"/>
          </xs:choice>
          <xs:sequence>
            <xs:choice>
              <xs:element name="rnc" type="cell:cellIdType"/>

```

```

        <xs:element name="lac" type="cell:cellIdType"/>
      </xs:choice>
      <xs:element name="cid" type="cell:cellIdType"/>
    </xs:sequence>
    <xs:element name="eucid" type="cell:cellIdType"/>
  </xs:choice>
  <xs:any namespace="##other" processContents="lax"
    minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:sequence>
  <xs:element name="nid" type="cell:cellIdType"/>
  <xs:element name="sid" type="cell:cellIdType"/>
  <xs:element name="baseid" type="cell:cellIdType"/>
  <xs:any namespace="##other" processContents="lax"
    minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:any namespace="##other" processContents="lax"
  minOccurs="0" maxOccurs="unbounded"/>
</xs:choice>
</xs:restriction>
</xs:complexContent>
</xs:complexType>

<xs:simpleType name="mccType">
  <xs:restriction base="xs:token">
    <xs:pattern value="[0-9]{3}"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="mncType">
  <xs:restriction base="xs:token">
    <xs:pattern value="[0-9]{2,3}"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="cellIdType">
  <xs:restriction base="xs:nonNegativeInteger">
    <xs:maxInclusive value="268435456"/> <!-- 2^28 (eucid) -->
  </xs:restriction>
</xs:simpleType>

<!-- Measurement Request elements -->

<xs:element name="type" type="cell:typeType"/>
<xs:simpleType name="typeType">
  <xs:restriction base="xs:token">
    <xs:enumeration value="gsm"/>
    <xs:enumeration value="umts"/>
    <xs:enumeration value="lte"/>
  </xs:restriction>
</xs:simpleType>

```

```

        <xs:enumeration value="cdma"/>
    </xs:restriction>
</xs:simpleType>

<xs:element name="network" type="cell:networkType"/>
<xs:complexType name="networkType">
    <xs:complexContent>
        <xs:restriction base="xs:anyType">
            <xs:choice>
                <xs:sequence>
                    <xs:element name="mcc" type="cell:mccType"/>
                    <xs:element name="mnc" type="cell:mncType"/>
                </xs:sequence>
                <xs:element name="nid" type="cell:cellIdType"/>
            </xs:choice>
        </xs:restriction>
    </xs:complexContent>
</xs:complexType>

</xs:schema>

```

---

<b>Cellular measurement schema</b>
------------------------------------

---



---

## 6.8. GNSS Measurement Schema

---

<a href="#">TOC</a>
---------------------

```

<?xml version="1.0"?>
<xs:schema
  xmlns:gnss="urn:ietf:params:xml:ns:geopriv:lm:gnss"
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:gnss"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:ns:geopriv:lm:gnss">
    </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a set of GNSS location measurements
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"/>

  <!-- GNSS -->
  <xs:element name="gnss" type="gnss:gnssMeasurementType">
    <xs:unique name="gnssSatellite">
      <xs:selector xpath="sat"/>
      <xs:field xpath="@num"/>
    </xs:unique>
  </xs:element>

  <xs:complexType name="gnssMeasurementType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="gnssTime" type="bt:nnDoubleWithRMSError"
            minOccurs="0"/>
          <xs:element name="sat" type="gnss:gnssSatelliteType"
            minOccurs="1" maxOccurs="64"/>
          <xs:any namespace="##other" processContents="lax"
            minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:attribute name="system" type="xs:token" use="required"/>
        <xs:attribute name="signal" type="xs:token"/>
        <xs:anyAttribute namespace="##any" processContents="lax"/>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

```

```

<xs:complexType name="gnssSatelliteType">
  <xs:complexContent>
    <xs:restriction base="xs:anyType">
      <xs:sequence>
        <xs:element name="doppler" type="bt:doubleWithRMSError"/>
        <xs:element name="codephase" type="bt:nnDoubleWithRMSError"/>
        <xs:element name="cn0" type="bt:nonNegativeDouble"/>
        <xs:element name="mp" type="bt:positiveDouble"
          minOccurs="0"/>
        <xs:element name="cq" type="gnss:codePhaseQualityType"
          minOccurs="0"/>
        <xs:element name="adr" type="xs:double" minOccurs="0"/>
      </xs:sequence>
      <xs:attribute name="num" type="xs:positiveInteger"
        use="required"/>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>

<xs:complexType name="codePhaseQualityType">
  <xs:complexContent>
    <xs:restriction base="xs:anyType">
      <xs:attribute name="continuous" type="xs:boolean"
        default="true"/>
      <xs:attribute name="direct" use="required">
        <xs:simpleType>
          <xs:restriction base="xs:token">
            <xs:enumeration value="direct"/>
            <xs:enumeration value="inverted"/>
          </xs:restriction>
        </xs:simpleType>
      </xs:attribute>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>
</xs:schema>

```

### GNSS measurement Schema

```

<?xml version="1.0"?>
<xs:schema
  xmlns:dsl="urn:ietf:params:xml:ns:geopriv:lm:dsl"
  xmlns:bt="urn:ietf:params:xml:ns:geopriv:lm:basetypes"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:lm:dsl"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
      source="urn:ietf:params:xml:schema:geopriv:lm:dsl">
        DSL measurement definitions
      </xs:appinfo>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
      <!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
        published RFC and remove this note.]] -->
      This schema defines a basic set of DSL location measurements.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:geopriv:lm:basetypes"/>

  <xs:element name="dsl" type="dsl:dslVlanType"/>
  <xs:complexType name="dslVlanType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:choice>
          <xs:element name="l2tp">
            <xs:complexType>
              <xs:complexContent>
                <xs:restriction base="xs:anyType">
                  <xs:sequence>
                    <xs:element name="src" type="bt:ipAddressType"/>
                    <xs:element name="dest" type="bt:ipAddressType"/>
                    <xs:element name="session"
                      type="xs:nonNegativeInteger"/>
                  </xs:sequence>
                </xs:restriction>
              </xs:complexContent>
            </xs:complexType>
          </xs:element>
          <xs:sequence>
            <xs:element name="an" type="xs:token"/>
            <xs:group ref="dsl:dslSlotPort"/>
          </xs:sequence>
          <xs:sequence>
            <xs:element name="stag" type="dsl:vlanIDType"/>

```

```

        <xs:choice>
          <xs:sequence>
            <xs:element name="ctag" type="dsl:vlanIDType"/>
            <xs:group ref="dsl:dslSlotPort" minOccurs="0"/>
          </xs:sequence>
          <xs:group ref="dsl:dslSlotPort"/>
        </xs:choice>
      </xs:sequence>
    <xs:sequence>
      <xs:element name="vpi" type="bt:byteType"/>
      <xs:element name="vci" type="bt:twoByteType"/>
    </xs:sequence>
    <xs:any namespace="##other" processContents="lax"
      minOccurs="0" maxOccurs="unbounded"/>
  </xs:choice>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:restriction>
</xs:complexContent>
</xs:complexType>
<xs:simpleType name="vlanIDType">
  <xs:restriction base="xs:nonNegativeInteger">
    <xs:maxInclusive value="4095"/>
  </xs:restriction>
</xs:simpleType>
<xs:group name="dslSlotPort">
  <xs:sequence>
    <xs:element name="slot" type="xs:token"/>
    <xs:element name="port" type="xs:token"/>
  </xs:sequence>
</xs:group>
</xs:schema>

```

#### DSL measurement schema

---



---

## 7. Privacy Considerations

[TOC](#)

Location-related measurement data can be as privacy sensitive as location information.

Measurement data is effectively equivalent to location information if the contextual knowledge necessary to generate one from the other is readily accessible. Even where contextual knowledge is difficult to acquire, there can be no assurance that an authorized recipient of the



contextual knowledge is also authorized to receive location information.

In order to protect the privacy of the subject of location-related measurement data, this implies that measurement data is protected with the same degree of protection as location information.

---

### 7.1. Measurement Data Privacy Model

[TOC](#)

It is less desirable to distribute measurement data in the same fashion as location information. Measurement data is less useful to location recipients than location information. Therefore, a simple distribution model is desirable.

In this simple model, the Device is the only entity that is able to distribute measurement data. To use an analogy from the GEOPRIV architecture, the Device - as the Location Generator (or the Measurement Data Generator) - is the sole entity that can assume the roles of Rule Maker and Location Server.

No entity can redistribute measurement data. The Device directs other entities in how measurement data is used and retained.

---

### 7.2. LIS Privacy Requirements

[TOC](#)

A LIS MUST NOT reveal location-related measurement data or location information based on measurement data to any other entity unless directed to do so by the Device.

By adding measurement data to a request for location information, the Device implicitly grants permission for the LIS to generate the requested location information using the measurement data. Permission to use this data for any other purpose is not implied.

As long as measurement data is only used in serving the request that contains it, rules regarding data retention are not necessary. A LIS MUST discard location-related measurement data after servicing a request, unless the Device grants permission to use that information for other purposes.

---

### 7.3. Measurement Data and Location URIs

[TOC](#)

A LIS MAY use measurement data provided by the Device to serve requests to location URIs, if the Device permits it. A Device permits this by including measurement data in a request that explicitly requests a location URI. By requesting a location URI, the Device grants

permission for the LIS to use the measurement data in serving requests to that URI.

**Note:** In HELD, the any type is not an explicit request for a location URI, though a location URI might be provided.

The usefulness of measurement data that is provided in this fashion is limited. The measurement data is only valid at the time that it was acquired by the Device. At the time that a request is made to a location URI, the Device might have moved, rendering the measurement data incorrect.

A Device is able to explicitly limit the time that a LIS retains measurement data by adding an expiry time to the measurement data, see [Section 4.1.2 \(Expiry Time on Location-Related Measurement Data\)](#).

---

## 7.4. Third-Party-Provided Measurement Data

[TOC](#)

An authorized third-party request for the location of a Device (see [\[I-D.ietf-geopriv-held-identity-extensions\] \(Winterbottom, J., Thomson, M., Tschofenig, H., and R. Barnes, "Use of Device Identity in HTTP-Enabled Location Delivery \(HELD\)," February 2010.\)](#)) can include location-related measurement data. This is possible where the third-party is able to make observations about the Device.

A third-party that provides measurement data MUST be authorized to provide the specific measurement for the identified device. A third-party MUST either be trusted by the LIS for the purposes of providing measurement data of the provided type, or the measurement data MUST be validated (see [Section 8.2.1 \(Measurement Validation\)](#)) before being used.

How a third-party authenticates its identity or gains authorization to use measurement data is not covered by this document.

---

## 8. Security Considerations

[TOC](#)

Use of location-related measurement data has privacy considerations that are discussed in [Section 7 \(Privacy Considerations\)](#).

---

### 8.1. Threat Model

[TOC](#)

The threat model for location-related measurement data concentrates on the Device providing falsified, stolen or incorrect measurement data.

A Device that provides location location-related measurement data might use data to:

- \*acquire the location of another Device, without authorization;
- \*extract information about network topology; or
- \*coerce the LIS into providing falsified location information based on the measurement data.

---

#### 8.1.1. Acquiring Location Information Without Authorization

[TOC](#)

Requiring authorization for location requests is an important part of privacy protections of a location protocol. A location configuration protocol usually operates under a restricted policy that allows a requester to obtain their own location. [HELD identity extensions \(Winterbottom, J., Thomson, M., Tschofenig, H., and R. Barnes, "Use of Device Identity in HTTP-Enabled Location Delivery \(HELD\)," February 2010.\)](#) [I-D.ietf-geopriv-held-identity-extensions] allows other entities to be authorized, conditional on a Rule Maker providing sufficient authorization.

The intent of these protections is to ensure that a location recipient is authorized to acquire location information. Location-related measurement data could be used by an attacker to circumvent such authorization checks if the association between measurement data and Target Device is not validated by a LIS.

A LIS can be coerced into providing location information for a Device that a location recipient is not authorized to receive. A request identifies one Device (implicitly or explicitly), but measurement data is provided for another Device. If the LIS does not check that the measurement data is for the identified Device, it could incorrectly authorize the request.

By using unvalidated measurement data to generate a response, the LIS provides information about a Device without appropriate authorization. The feasibility of this attack depends on the availability of information that links a Device with measurement data. In some cases, measurement data that is correlated with a target is readily available. For instance, [LLDP measurements \(LLDP Measurements\)](#) are broadcast to all nodes on the same network segment. An attacker on that network segment can easily gain measurement data that relates a Device with measurements.

For some types of measurement data, it's necessary for an attacker to know the location of the target in order to determine what measurements to use. This attack is meaningless for types of measurement data that require that the attacker first know the location of the target before measurement data can be acquired or fabricated. [GNSS measurements \(GNSS](#)

[Measurements](#)) share this trait with many wireless location determination methods.

---

### 8.1.2. Extracting Network Topology Data

[TOC](#)

Allowing requests with measurements might be used to collect information about a network topology. This is possible if requests containing measurements are permitted.

Network topology can be considered sensitive information by a network operator for commercial or security reasons. While it is impossible to completely prevent a Device from acquiring some knowledge of network topology if a location service is provided, a network operator might desire to limit how much of this information is made available. Mapping a network topology does not require that an attacker be able to associate measurement data with a particular Device. If a requester is able to try a number of measurements, it is possible to acquire information about network topology.

It is not even necessary that the measurements are valid; random guesses are sufficient, provided that there is no penalty or cost associated with attempting to use the measurements.

---

### 8.1.3. Lying By Proxy

[TOC](#)

Location information is a function of its inputs, which includes measurement data. Thus, falsified measurement data can be used to alter the location information that is provided by a LIS.

Some types of measurement data are relatively easy to falsify in a way that the resulting location information to be selected with little or no error. For instance, GNSS measurements are easy to use for this purpose because all the contextual information necessary to calculate a position using measurements is broadcast by the satellites [\[HARPER\]](#) (Harper, N., Dawson, M., and D. Evans, "Server-side spoofing and detection for Assisted-GPS," December 2009.).

An attacker that falsifies measurement data gains little if they are the only recipients of the result. The attacker knows that the location information is bad. The attacker only gains if the information can somehow be attributed to the LIS by another location recipient.

A recipient might evaluate the trustworthiness of the location information based on the credibility of its source. By coercing the LIS into providing falsified location information, any credibility that the LIS might have - that the attacker does not - is gained by the attacker.

A third-party that is reliant on the integrity of the location information might base an evaluation of the credibility of the

information on the source of the information. If that third party is able to attribute location information to the LIS, then an attacker might gain.

Location information that is provided to the Device without any means to identify the LIS as its source is not subject to this attack. The Device is identified as the source of the data when it distributes the location information to location recipients.

An attacker gains if they are able to coerce the LIS into providing location information based on falsified measurement data and that information can be attributed to the LIS.

Location information is attributed to the LIS either through the use of digital signatures or by having the location recipient directly interact with the LIS. A LIS that digitally signs location information becomes identifiable as the source of the data. Similarly, the LIS is identified as a source of data if a location recipient acquires information directly from a LIS using a location URI.

---

#### **8.1.4. Measurement Replay**

[TOC](#)

The value of some measured properties do not change over time for a single location. This allows for simple replay attacks, where an attacker acquires measurements that can later be used without being detected as being invalid.

Measurement data is frequently an observation of an time-invariant property of the environment at the subject location. For measurements of this nature, nothing in the measurement itself is sufficient proof that the Device is present at the resulting location. Measurement data might have been previously acquired and reused.

For instance, the identity of a radio transmitter, if broadcast by that transmitter, can be collected and stored. An attacker that wishes it known that they exist at a particular location, can claim to observe this transmitter at any time. Nothing inherent in the claim reveals it to be false.

For properties of a network, time-invariance is often directly as a result of the practicalities of operating the network. Limiting the changes to a network ensures greater consistency of service. A largely static network also greatly simplifies the data management tasks involved with providing a location service.

---

## **8.2. Mitigation**

[TOC](#)

The following measures can be applied to limit or prevent attacks. The effectiveness of each depends on the type of measurement data and how that measurement data is acquired.

Two general approaches are identified for dealing with untrusted measurement data:

1. Require independent validation of measurement data or the location information that is produced.
2. Identify the types of sources that provided the measurement data that location information was derived from.

This section goes into more detail on the different forms of validation in [Section 8.2.1 \(Measurement Validation\)](#), [Section 8.2.2 \(Location Validation\)](#), and [Section 8.2.3 \(Supporting Observations\)](#). The impact of attributing location information to sources is discussed in more detail in [Section 8.2.4 \(Attribution\)](#).

---

### 8.2.1. Measurement Validation

[TOC](#)

Detecting that measurement data has been falsified is difficult in the absence of integrity mechanisms.

Independent confirmation of the veracity of measurement data ensures that the measurement is accurate and that it applies to the correct Device. By gathering the same measurement data from a trusted and independent source, the LIS is able to check that the measurement data is correct.

Measurement information might contain no inherent indication that it is falsified. On the contrary, it can be difficult to obtain information that would provide any degree of assurance that the measurement device is physically at any particular location. Measurements that are difficult to verify require other forms of assurance before they can be used.

---

#### 8.2.1.1. Effectiveness

[TOC](#)

Measurement validation MUST be used if measurement data for a particular Device can be easily acquired by unauthorized location recipients, as described in [Section 8.1.1 \(Acquiring Location Information Without Authorization\)](#). This prevents unauthorized access to location information using measurement data.

Validation of measurement data can be significantly more effective than independent acquisition of the same. For instance, a Device in a large Ethernet network could provide a measurement indicating its point of attachment using LLDP measurements. For a LIS, acquiring the same measurement data might require a request to all switches in that

network. With the measurement data, validation can target the identified switch with a specific query.

Validation is effective in identifying [falsified measurement data \(Lying By Proxy\)](#), including attacks involving [replay of measurement data \(Measurement Replay\)](#). Validation also limits the amount of [network topology information \(Extracting Network Topology Data\)](#) made available to Devices to that portion of the network topology that they are directly attached.

---

#### 8.2.1.2. Limitations (Unique Observer)

[TOC](#)

A Device is often in a unique position to make a measurement. It alone occupies the point in space-time that the location determination process seeks to determine. The Device becomes a unique observer for a particular property.

The ability of the Device to become a unique observer makes the Device invaluable to the location determination process. As a unique observer, it also makes the claims of a Device difficult to validate and easily to spoof.

As long as no other entity is capable of making the same measurements, there is also no other entity that can independently check that the measurements are correct and applicable to the Device. A LIS might be unable to validate all or part of the measurement data it receives from a unique observer. For instance, a signal strength measurement of the signal from a radio tower cannot be validated directly.

Some portion of the measurement data might still be independently verified, even if all information cannot. In the previous example, the radio tower might be able to provide verification that the Device is present if it is able to observe a radio signal sent by the Device. If measurement data can only be partially validated, the extent to which it can be validated determines the effectiveness of validation against these attacks.

The advantage of having the Device as a unique observer is that it makes it difficult for an attacker to acquire measurements without the assistance of the Device. Attempts to use measurements to gain [unauthorized access to measurement data \(Acquiring Location Information Without Authorization\)](#) are largely ineffectual against a unique observer.

---

#### 8.2.2. Location Validation

[TOC](#)

Location information that is derived from location-related measurement data can also be verified against trusted location information. Rather

than validating inputs to the location determination process, suspect locations are identified at the output of the process.

Trusted location information is acquired using sources of measurement data that are trusted. Untrusted location information is acquired using measurement data provided from untrusted sources, which might include the Device. These two locations are compared. If the untrusted location agrees with the trusted location, the untrusted location information is used.

Algorithms for the comparison of location information are not included in this document. However, a simple comparison for agreement might require that the untrusted location be entirely contained within the uncertainty region of the trusted location.

There is little point in using a less accurate, less trusted location. Untrusted location information that has worse accuracy than trusted information can be immediately discarded. There are multiple factors that affect accuracy, uncertainty and currency being the most important. How location information is compared for accuracy is not defined in this document.

---

#### **8.2.2.1. Effectiveness**

[TOC](#)

Location validation limits the extent to which falsified - or erroneous - measurement data can cause an incorrect location to be reported. Location validation can be more efficient than validation of inputs, particularly for a [unique observer \(Limitations \(Unique Observer\)\)](#). Validating location ensures that the Device is at or near the resulting location. Location validation can be used to limit or prevent all of the attacks identified in this document.

---

#### **8.2.2.2. Limitations**

[TOC](#)

The trusted location that is used for validation is always less accurate than the location that is being checked. The amount by which the untrusted location is more accurate, is the same amount that an attacker can exploit.

For example, a trusted location might indicate a five kilometer radius uncertainty region. An untrusted location that describes a 100 meter uncertainty within the larger region might be accepted as more accurate. An attacker might still falsify measurement data to select any location within the larger uncertainty region. While the 100 meter uncertainty that is reported seems more accurate, a falsified location could be anywhere in the five kilometer region.

Where measurement data might have been falsified, the actual uncertainty is effectively much higher. Local policy might allow



differing degrees of trust to location information derived from untrusted measurement data. This might not be a boolean operation with only two possible outcomes: untrusted location information might be used entirely or not at all, or it could be combined with trusted location information with the degree to which each contributes based on a value set in local policy.

---

### 8.2.3. Supporting Observations

[TOC](#)

Replay attacks using previously acquired measurement data are particularly hard to detect without independent validation. Rather than validate the measurement data directly, supplementary data might be used to validate measurements or the location information derived from those measurements.

These supporting observations could be used to convey information that provides additional assurance that the Device was acquired at a specific time and place. In effect, the Device is requested to provide proof of its presence at the resulting location.

For instance, a Device that measures attributes of a radio signal could also be asked to provide a sample of the measured radio signal. If the LIS is able to observe the same signal, the two observations could be compared. Providing that the signal cannot be predicted in advance by the Device, this could be used to support the claim that the Device is able to receive the signal. Thus, the Device is likely to be within the range that the signal is transmitted. A LIS could use this to attribute a higher level of trust in the associated measurement data or resulting location.

---

#### 8.2.3.1. Effectiveness

[TOC](#)

The use of supporting observations is limited by the ability of the LIS to acquire and validate these observations. The advantage of selecting observations independent of measurement data is that observations can be selected based on how readily available the data is for both LIS and Device. The amount and quality of the data can be selected based on the degree of assurance that is desired.

Use of supporting observations is similar to both measurement validation and location validation. All three methods rely on independent validation of one or more properties. Applicability of each method is similar.

Use of supporting observations can be used to limit or prevent all of the attacks identified in this document.

---

#### 8.2.3.2. Limitations

[TOC](#)

The effectiveness of the validation method depends on the quality of the supporting observation: how hard it is to obtain at a different time or place, how difficult it is to guess and what other costs might be involved in acquiring this data.

In the example of an observed radio signal, requesting a sample of the signal only provides an assurance that the Device is able to receive the signal transmitted by the measured radio transmitter. This only provides some assurance that the Device is within range of the transmitter.

As with location validation, a Device might still be able to provide falsified measurements that could alter the value of the location information as long as the result is within this region.

Requesting additional supporting observations can reduce the size of the region over which location information can be altered by an attacker, or increase trust in the result, but each additional has a cost. Supporting observations contribute little or nothing toward the primary goal of determining the location of the Device. Any costs in acquiring supporting observations are balanced against the degree of integrity desired of the resulting location information.

---

#### 8.2.4. Attribution

[TOC](#)

[Lying by proxy \(Lying By Proxy\)](#) relies on the location recipient being able to attribute location information to a LIS. The effectiveness of this attack is negated if location information is explicitly attributed to a particular source.

This requires an extension to the location object that explicitly identifies the source (or sources) of each item of location information.

Rather than relying on a process that seeks to ensure that location information is accurate, this approach instead provides a location recipient with the information necessary to reach their own conclusion about the trustworthiness of the location information.

Including an authenticated identity for all sources of measurement data presents a number of technical and operational challenges. It is possible that the LIS has a transient relationship with a Device. A Device is not expected to share authentication information with a LIS. There is no assurance that Device identification is usable by a potential location recipient. Privacy concerns might also prevent the sharing of identification information, even if it were available and usable.

Identifying the type of measurement source allows a location recipient to make a decision about the trustworthiness of location information

without depending on having authenticated identity information for each source. An element for this purpose is defined in [Section 4.4 \(Identifying Location Provenance\)](#).

When including location information that is based on measurement data from sources that might be untrusted, a LIS SHOULD include alternative location information that is derived from trusted sources of measurement data. Each item of location information can then be labelled with the source of that data.

A location recipient that is able to identify a specific source of measurement data (whether it be LIS or Device) can use this information to attribute location information to either or both entity. The location recipient is then better able to make decisions about trustworthiness based on the source of the data.

A location recipient that does not understand the source element is unable to make this distinction. When constructing a PIDF-LO document, trusted location information MUST be placed in the PIDF-LO so that it is given higher priority to any untrusted location information according to Rule #8 of [\[RFC5491\] \(Winterbottom, J., Thomson, M., and H. Tschofenig, "GEOPRIV Presence Information Data Format Location Object \(PIDF-LO\) Usage Clarification, Considerations, and Recommendations," March 2009.\)](#).

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#### 8.2.5. Stateful Correlation of Location Requests

[TOC](#)

Stateful examination of requests can be used to prevent a Device from attempting to map network topology using requests for location information ([Section 8.1.2 \(Extracting Network Topology Data\)](#)). Simply limiting the rate of requests from a single Device reduces the amount of data that a Device can acquire about network topology.

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### 9. IANA Considerations

[TOC](#)

This section creates a registry for [GNSS types \(GNSS Measurements\)](#) and registers the namespaces and schema defined in [Section 6 \(Measurement Schemas\)](#).

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#### 9.1. IANA Registry for GNSS Types

[TOC](#)

This document establishes a new IANA registry for Global Navigation Satellite System (GNSS) types. The registry includes tokens for the GNSS type and for each of the signals within that type. Referring to

[\[RFC5226\]](#) ([Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs," May 2008.](#)), this registry operates under "Specification Required" rules. The IESG will appoint an Expert Reviewer who will advise IANA promptly on each request for a new or updated GNSS type.

Each entry in the registry requires the following information:

**GNSS name:** the name and a brief description of the GNSS

**Brief description:** the name and a brief description of the GNSS

**GNSS token:** a token that can be used to identify the GNSS

**Signals:** a set of tokens that represent each of the signals that the system provides

**Documentation reference:** a reference to one or more stable, public specifications that outline usage of the GNSS, including (but not limited to) signal specifications and time systems

The registry initially includes two registrations:

**GNSS name:** Global Positioning System (GPS)

**Brief description:** a system of satellites that use spread-spectrum transmission, operated by the US military for commercial and military applications

**GNSS token:** gps

**Signals:** L1, L2, L1C, L2C, L5

**Documentation reference:** [Navstar GPS Space Segment/Navigation User Interface](#) ([, "Navstar GPS Space Segment/Navigation User Interface," Apr 2000.](#)) [GPS.ICD]

**GNSS name:** Galileo

**Brief description:** a system of satellites that operate in the same spectrum as GPS, operated by the European Union for commercial applications

**GNSS Token:** galileo

**Signals:** L1, E5A, E5B, E5A+B, E6

**Documentation Reference:** [Galileo Open Service Signal In Space Interface Control Document \(SIS ICD\)](#) ([GJU, "Galileo Open Service Signal In Space Interface Control Document \(SIS ICD\)," May 2006.](#)) [Galileo.ICD]

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## 9.2. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc, as per the guidelines in  
[\[RFC3688\]](#) (Mealling, M., "The IETF XML Registry," January 2004.).

URI: urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```
BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>Measurement Source for PIDF-L0</title>
    </head>
    <body>
      <h1>Namespace for Location Measurement Source</h1>
      <h2>urn:ietf:params:xml:ns:pidf:geopriv10:lmsrc</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END
```

---

## 9.3. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm, as per the guidelines in [\[RFC3688\]](#)  
(Mealling, M., "The IETF XML Registry," January 2004.).

URI: urn:ietf:params:xml:ns:geopriv:lm

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```
BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>Measurement Container</title>
    </head>
    <body>
      <h1>Namespace for Location Measurement Container</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END
```

---

#### 9.4. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:basetypes

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:basetypes, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:basetypes

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>Base Device Types</title>
    </head>
    <body>
      <h1>Namespace for Base Types</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:basetypes</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXX</a>.</p>
    </body>
  </html>
END

```

## 9.5. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:lldp

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:lldp, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:lldp

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>LLDP Measurement Set</title>
    </head>
    <body>
      <h1>Namespace for LLDP Measurement Set</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:lldp</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXX</a>.</p>
    </body>
  </html>
END

```

## 9.6. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:dhcp

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:dhcp, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:dhcp

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:



```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>DHCP Measurement Set</title>
    </head>
    <body>
      <h1>Namespace for DHCP Measurement Set</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:dhcp</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END

```

## 9.7. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:wifi

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:wifi, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:wifi

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>WiFi Measurement Set</title>
    </head>
    <body>
      <h1>Namespace for WiFi Measurement Set</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:wifi</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END

```

## 9.8. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:cell

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:cell, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:cell

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>Cellular Measurement Set</title>
    </head>
    <body>
      <h1>Namespace for Cellular Measurement Set</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:cell</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END

```

## 9.9. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:gnss

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:gnss, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:gnss

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>GNSS Measurement Set</title>
    </head>
    <body>
      <h1>Namespace for GNSS Measurement Set</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:gnss</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END

```

## 9.10. URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:lm:dsl

[TOC](#)

This section registers a new XML namespace,  
urn:ietf:params:xml:ns:geopriv:lm:dsl, as per the guidelines in  
[\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

URI: urn:ietf:params:xml:ns:geopriv:lm:dsl

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),  
Martin Thomson (martin.thomson@andrew.com).

XML:

```

BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>DSL Measurement Set</title>
    </head>
    <body>
      <h1>Namespace for DSL Measurement Set</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:lm:dsl</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END

```

---

### 9.11. XML Schema Registration for Measurement Source Schema

[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\]](#) (Mealling, M., "The IETF XML Registry," January 2004.).

**URI:** urn:ietf:params:xml:schema:pidf:geopriv10:lm:src

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:** The XML for this schema can be found in [Section 6.2](#) ([Measurement Source Schema](#)) of this document.

---

### 9.12. XML Schema Registration for Measurement Container Schema

[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\]](#) (Mealling, M., "The IETF XML Registry," January 2004.).

**URI:** urn:ietf:params:xml:schema:lm

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:**

The XML for this schema can be found in [Section 6.1 \(Measurement Container Schema\)](#) of this document.

---

**9.13. XML Schema Registration for Base Types Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:basetypes

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:** The XML for this schema can be found in [Section 6.3 \(Base Type Schema\)](#) of this document.

---

**9.14. XML Schema Registration for LLDP Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:lldp

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:** The XML for this schema can be found in [Section 6.4 \(LLDP Measurement Schema\)](#) of this document.

---

**9.15. XML Schema Registration for DHCP Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:dhcp

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:**

The XML for this schema can be found in [Section 6.5 \(DHCP Measurement Schema\)](#) of this document.

---

**9.16. XML Schema Registration for WiFi Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:wifi

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:** The XML for this schema can be found in [Section 6.6 \(WiFi Measurement Schema\)](#) of this document.

---

**9.17. XML Schema Registration for Cellular Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:cellular

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:** The XML for this schema can be found in [Section 6.7 \(Cellular Measurement Schema\)](#) of this document.

---

**9.18. XML Schema Registration for GNSS Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:gnss

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:**

The XML for this schema can be found in [Section 6.8 \(GNSS Measurement Schema\)](#) of this document.

---

**9.19. XML Schema Registration for DSL Schema**[TOC](#)

This section registers an XML schema as per the guidelines in [\[RFC3688\] \(Mealling, M., "The IETF XML Registry," January 2004.\)](#).

**URI:** urn:ietf:params:xml:schema:lm:dsl

**Registrant Contact:** IETF, GEOPRIV working group,  
(geopriv@ietf.org), Martin Thomson (martin.thomson@andrew.com).

**Schema:** The XML for this schema can be found in [Section 6.9 \(DSL Measurement Schema\)](#) of this document.

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**10. Acknowledgements**[TOC](#)

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